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Economic analysis of tissue cultured banana (*Musa* × *paradisiaca*) production under the influence of integrated nutrient management

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ABSTRACT

An experiment was conducted to evaluate various integrated nutrient management packages to evaluate the yield, quality and economics of banana (*Musa* × *paradisaca* L.) cultivation during 2008-2010. The response of INM on economics of tissue cultured banana cv. Grand Naine indicated that the overall cost of cultivation as well as economics of banana production was significantly influenced by integration of biofertilizers, organic manure and inorganic fertilizers. Among the different treatments, highest expenditure of ₹ 264 110.00 per ha was incurred in 100% RDF + VAM + *Azospirillum* + PSB + *Trichoderma harzianum*. However, the same treatment recorded the highest gross as well as net income. In spite of maximum cost of cultivation, the highest cost benefit ratio of 4.22:1was also recorded in this treatment, followed by 75% RDF +VAM + *Azospirillum* + PSB + *Trichoderma harzianum*.

Key words: Banana, Bio-fertilizer, Cost of cultivation, Economics, Grand Naine, INM

Banana (*Musa* × *paradisiaca* L.) is an important fruit crop of tropical and sub-tropical regions of the world. India is the largest producer of banana in the world contributing 17.3 percent to the global production (Kumar *et al.* 2008). Among all the fruits, banana is plentiful, most nourishing and relatively a cheaper source of nearly all essential nutrients including vitamins and minerals and rich source of energy. It provides a more balanced diet containing sufficient amount of carbohydrates and essential nutrients including minerals, vitamins (Hazarika 2011). Being a soil-exhausting crop, judicious application of nutrients is of paramount importance to ensure high yield. Banana exhausts macro and micronutrient from soil in large quantities hence, requires continuous replenishment (Thangaselvabai *et al.* 2009b). Supplying of optimum nutrients is responsible for healthy and robust vegetative frame which is prerequisite for production of high yield in banana (Thangaselvabai *et al.* 2009a). Integrated plant nutrient supply system encourages integration of different sources of nutrients such as organic, biological and inorganic fertilizers etc. In recent years, decline in soil health with respect to physical, chemical and biological properties is evident due to indiscriminate use of nutrients, particularly chemical fertilizers (Patel *et al.* 2009). Plant growth is often hindered owing to insufficient resident microflora which acts as both source and sinks for essential plant nutrients and is fundamental to the transformation of various nutrients either inherited from soil or applied through anthropogenic sources. The utility of microbes in maintenance and built up of soil fertility, thereby, enhancing plant growth and yield is indispensable (Marathe *et al.* 2011). Although chemical fertilizers contribute a lot in fulfilling the nutrient requirement but their regular, excessive and unbalanced use may lead to health and ecological hazards, depletion of physico-chemical properties of the soil and ultimately poor crop yields (Singh and Singh 2009). In addition, excess fertilization could be the main cause of pollution in surface and ground water as well as soil and now become diseased and desolate under the influence of indiscriminate and uncontrolled use of inorganic fertilizers (Hazarika *et al.* 2011). Hence, there is an urgent need to think of alternate source of safe fertilizers which may enhance crop yields without having adverse effects on soil properties. Thus, the use of bio-fertilizers seems to be array of hope in this direction. Biofertilizers have been considered as a cheap, eco-friendly way of improving soil fertility status. Biofertilizers like *Azotobacter* fix atmospheric nitrogen and enhances the production of various field crops (Umar *et al.* 2009). N-fixing bacteria possess unique potential of fixing atmospheric nitrogen either by living symbiotically or non-symbiotically or to transform native soil nutrients, from non-usable to usable form through biological process (Marwaha 1995). Furthermore, *Azotobacter* and *Azospirillum* have also been found to promote synthesis of growth promoting substances like auxins, gibberellins,

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Table 1 Comparative yield potentiality of different treatments and cost benefit ratio

Treatment	Yield (t/ha)	Percentage yield increase over control	Sucker production	Gross expenditure (₹)	Gross income (₹)	Net income (₹)	C: B ratio
T_0	40.33		4.53	191 162.10	744 745.80	553 583.70	2.89
T_1	54.11	34.17	5.40	239 175.12	978 290.00	739 114.88	3.09
T_2	55.96	38.75	5.80	265 668.43	1 018 388.00	752 719.57	2.83
T_3	56.78	40.79	5.93	245 408.84	1 034 699.80	789 290.96	3.21
T_4	60.48	49.96	6.47	245 408.84	1 106 864.20	861 455.36	3.51
T_5	60.69	50.48	6.53	245 408.84	1 111 865.80	866 456.96	3.53
T_6	61.10	51.50	6.73	245 408.84	1 124 187.80	878 778.96	3.58
T_7	59.81	48.30	6.60	257 876.28	1 100 826.00	842 949.72	3.26
T_8	75.35	86.83	8.07	264 110.00	1 379 290.20	1 115 180.20	4.22
T_9	69.10	71.34	7.73	252 675.01	1 275 047.80	1 022 372.79	4.05
T_{10}	63.06	56.36	7.20	241 240.03	1 168 092.00	926 851.97	3.84

cytokinins and antibiotic metabolites which, in turn, improved resistance against biotic and abiotic stress (Awasthi *et al.* 1998). Inoculation of these N -fixing microorganisms in the soil not only increases the yield but also save 20-40% nitrogen inputs. Likewise, application of organic manures like FYM to soil not only improve soil physical properties, pH, water holding capacity but also add important nutrients to the soil, thus increase the nutrient availability and its ultimate absorption by plant. The organic manures and biofertilizers help in better utilization of added inorganic fertilizers thus reduce its level of application as well as reduce the deleterious effect of harsh chemical residues that the inorganic fertilizers leave in the soil (Umar 2007). A judicious use of organic manures and biofertilizers may be effective not only in sustaining crop productivity and in soil health, but also in supplementing chemical fertilizers of the crops (Jaipaul *et al*. 2011). Hence, balance between efficient and productive agricultural enterprise and environmental protection and sustainability is very much important to make agriculture sector an economically viable venture (Yadav *et al.* 2013).

Agro-climatic condition of Mizoram is suitable for cultivation of banana but productivity in the state is rather low than any other parts of the country due to poor management, traditional system of cultivation, injudicious and imbalanced use of chemical fertilizers (Hazarika *et al.* 2011). In Mizoram, Grand Naine, a recently introduced variety is well known to the people for its excellent quality. Though it is a paying crop but its low productivity is a limiting factor for commercial cultivation in the region. In the state, the requirement of nutrients of banana through integration of organic manures along with biofertilizers, bioagents and inorganic fertilizers is not well documented. Taking productivity into consideration, and keeping in view all the above background information and research gaps, the present experiment was conducted to study the effect of best suitable integrated nutrient management practices with respect to economics of production for maximum benefit to farmers for micro-propagated banana cultivar Grand Naine under Mizoram, India.

MATERIALS AND METHODS

The present study was conducted at Experimental farm, Department of Horticulture, Aromatic and Medicinal Plants, Mizoram University, Aizawl, India during 2008 to 2010 with banana cv Grand Naine. Well rotten FYM @ 15 kg per pit and vermicompost @ 2 kg/pit was applied before planting as per treatment. Biofertilizers and bioagents, viz. *Azospirillum*, PSB, VAM and *Trichoderma harzianum* procured from Amit Biotech Pvt Ltd, Kolkata each @ 50 g/ plant were amended in the soil at the time of planting following treatment schedule. The recommended dose of fertilizers @ 200 g N, 100 g P_2O_5 and 300 g K_2O per plant as urea, SSP and MOP respectively, were applied in split doses. Whole of P_2O_5 along with half of K_2O were applied at the time of planting. Rest half were applied at eight month after planting, i e at shooting. Nitrogenous fertilizer were applied in three splits, i e 100 g one month after planting, 50 g four month after planting and 50 g seven month after planting.

The soil (0-30 cm) of the experimental plot was sandy loam; the available N, P and K were 274.20 kg/ha, 25.20 kg/ha and 126.93 kg/ha with 0.61% organic carbon and the soil was acidic in reaction with pH 4.82. The experimental field was situated at 23°44´45.6´´ N latitudes and 92°41´04.5´´ E longitudes and the elevation was 855 m above msl. Tissue cultured seedlings, procured from the Dept. of Horticulture, Government of Mizoram, after secondary hardening were planted at a spacing of 1.8 × 1.8 m. The experiment was laid out in a Randomized Block Design (RBD) with eleven treatments and three replications. The various treatments comprising of organic manures, biofertilizers and inorganic fertilizers were as follows: T_0 = Control (Without any fertilizer), T_1 = 100% Recommended dose of NPK + FYM (RDF), T_2 = 100% Recommended dose of NPK + Vermicompost, T_3 = 100% RDF + *Azospirillum* T_4 = 100% RDF + *Trichoderma harzianum*, T_5 = 100% RDF + VAM, T_6= 100% RDF + PSB, T_7 = 100%

RDF + VAM + *Azospirillum* + PSB, T_8 = 100% RDF + VAM + *Azospirillum* + PSB + *Trichoderma harzianum,* T_9 = 75% RDF + VAM + *Azospirillum* + PSB + *Trichoderma harzianum,* T_{10} = 50% RDF + VAM + *Azospirillum* + PSB + *Trichoderma harzianum.* Standard procedures were adopted for taking observations on various growth and yield characters. Five plants from the middle of each plot were selected randomly for recording observation on plant growth characters. Observations were taken at 3 months, 5 months and at shooting stage for growth and developmental characters. Matured bunches were harvested and data on weight of the bunch were estimated as per standard methods. The yield per hectare was calculated by multiplying the average bunch weight with the total number of plants per hectare and expressed in tonnes per hectare. The economics of the individual treatment was calculated based on the total cost of cultivation and gross income and were expressed on per hectare basis. The expenditures both recurring and non-recurring required during the cropping period were computed based on the investment on preparatory cost including planting materials. Net return was calculated by subtracting gross expenditure from the gross return on per hectare basis. The cost benefit ratio was calculated from the value of total expenditure and gross return based on the benefit obtained on per rupee cost in different treatments separately.

RESULTS AND DISCUSSION

Economics of cultivation is the most important single factor which decides the adoption of any improved practices by the grower. The cost-benefit ratio of treatments is another most important factor that determines its usefulness and acceptance by the grower. A treatment should not only be effective but also should be profitable proposition to be acceptance by a grower. In the present study, the different treatments showed clear impact on the comparative economics of the production of banana under the influence of inorganic fertilizers, organic manures, vermicompost and bio fertilizers. The details pertaining to costs and returns of integrated nutrient management of banana are given in Table 2.

Yield analysis

The pooled yield data pertaining to the banana production under the influence of different combinations of organic manure, inorganic fertilizers, biofertilizers and bioagents are given in Table 1. From the data, it is evident that the treatment 100% RDF + VAM + *Azospirillum* + PSB + *Trichoderma harzianum* recorded significantly highest yield (75.35 tonnes/ha) compared to other treatments followed by 75% RDF + VAM + *Azospirillum* + PSB + *Trichoderma harzianum*, 50% RDF + VAM + *Azospirillum* + PSB + *Trichoderma harzianum* and 100% RDF + PSB, whereas, the lowest (40.33 tonnes/ha) yield was recorded in control (T_0). Treatment with 100% RDF + VAM + *Azospirillum* + PSB + *Trichoderma harzianum* recorded an increased yield of 86.83% over control as against the lowest increase of 34.17% in 100% RDF (T_1). The economics under various treatments are worked out on the basis of yield under each individual treatment and are presented in Table 1.

Gross expenditure

Among all the treatments, the highest gross expenditure of ₹ 265 668.43 per ha was incurred in 100 % Recommended dose of NPK + vermicompost followed by 100% RDF + VAM + *Azospirillum* + PSB + *Trichoderma harzianum* (₹ 264 110.00) and lowest of ₹ 191 162.10 per ha in control.

Gross return

INM package with 100% RDF + VAM + *Azospirillum* + PSB + *Trichoderma harzianum* recorded highest gross returns in monetary terms (₹ 1 379 290.20) followed by 75 % RDF + VAM + *Azospirillum* + PSB + *Trichoderma harzianum* (₹ 1 275 047.80) and the lowest (₹ 7 44 745.00) was in control.

Net return

The net return is the main parameter for deciding the adoptability of a farming system. The highest net income of ₹ 1 115 180.20 per ha was obtained with 100% RDF + VAM + *Azospirillum* + PSB + *Trichoderma harzianum* followed by ₹ 1 022 372.79 per ha under 75% RDF + VAM + *Azospirillum* + PSB + *Trichoderma harzianum* (T_9). The lowest net income of ₹ 553 583.70 was recorded in control (T_0).

Benefit-cost analysis

The evaluation of relative merit of integration of inorganic fertilizers, organic manures, vermicompost with biofertilizers, biocontrol agents in the present study in augmenting yield and thereby income. The data presented in Table 1 revealed that in spite of an maximum cost of cultivation with an expenditure of ₹ 264 110.00/ha the maximum cost benefit ratio of 4.22: 1 was obtained in 100% RDF + VAM + *Azospirillum* + PSB + *Trichoderma harzianum* (T_8), followed by 4.05: 1 in 75 % RDF + VAM + *Azospirillum* + PSB + *Trichoderma harzianum* (T_9). The highest ratio in T_8 might be due to the comparatively higher yield of 75.35 tonnes/ha as well as highest number of sucker production per hectare (24 904.02) which ultimately increases the cost benefit ratio. Among all the treatments, the lowest of 2.83:1 in 100 % recommended dose of NPK + vermicompost (T_2). The lowest benefit: cost ratio in this treatment was mainly due to high gross expenditure with comparatively lower yield (55.96 tonnes/ha) as well as less sucker production per hectare (17 898.80) which together brings the net income lowering down (₹ 752 719.57). Similarly, in treatment T_0, although there was no involvement of input cost but due to very low yields (40.33 tonnes/ha) as well as lowest sucker production per hectare (13 979.58) the cost benefit ratio was lower (2.89: 1) with a net income of ₹ 553 583.70 per hectare .

Economic benefit of any farming system is the major

Table 2 Details of economics of cultivation per hectare (In ₹)

Plant Population per ha: 3086 Spacing: 1.8 m × 1.8 m, wages: Rs 150 per manday.

Items	Treatments										
	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
Cost of Land preparation	56660.00	56660.00	56660.00	56660.00	56660.00	56660.00	56660.00	56660.00	56660.00	56660.00	56660.00
Planting materials	61720.00	617200.00	617200.00	617200.00	617200.00	617200.00	617200.00	617200.00	617200.00	617200.00	617200.00
FYM and vermicompost		23145.00	49376.00	23145.00	23145.00	23145.00	23145.00	23145.00	23145.00	17358.75	11572.50
Inorganic fertilizers		24392.05	24392.05	24392.05	24392.05	24392.05	24392.05	24392.05	24392.05	18856.53	13321.02
Biofertilizers				6172.00	6172.00	6172.00	6172.00	18516.00	24688.00	24688.00	24688.00
Inter cultural operations	61290.00	61290.00	61290.00	61290.00	61290.00	61290.00	61290.00	61290.00	61290.00	61290.00	61290.00
Plant protection chemicals	2100.00	2100.00	2100.00	2100.00	2100.00	2100.00	2100.00	2100.00	2100.00	2100.00	2100.00
Harvesting	7500.00	7500.00	7500.00	7500.00	7500.00	7500.00	7500.00	7500.00	7500.00	7500.00	7500.00
Total expenditure	189270.00	236807.05	263038.05	242979.05	242979.05	242979.05	242979.05	255323.05	261495.05	250173.28	238851.52
Miscellaneous cost (1% of total expenditure)	1892.10	2368.07	2630.38	2429.79	2429.79	2429.79	2429.79	2553.23	2614.95	2501.73	2388.51
Grosss expenditure	191162.10	239175.12	265668.43	245408.84	245408.84	245408.84	245408.84	257876.28	264110.00	252675.01	241240.03
Yield (t/ha)	40.33	54.11	55.96	56.78	60.48	60.69	61.10	59.81	75.35	69.10	63.06
Return @₹ 15 000/t	604950.00	811650.00	839400.00	851700.00	907200.00	910350.00	916500.00	897150.00	1130250.00	1036500.00	945900.00
Sucker production per hectare	13979.58	16664.40	17898.80	18299.98	19966.42	20151.58	20768.78	20367.60	24904.02	23854.78	22219.20
Return @ ₹ 10/ sucker	139795.80	166640.00	178988.00	182999.80	199664.20	201515.80	207687.80	203676.00	249040.20	238547.80	222192.00
Gross Income (₹)	744745.80	978290.00	1018388.00	1034699.80	1106864.20	1111865.80	1124187.80	1100826.00	1379290.20	1275047.80	1168092.00
Net income	553583.70	739114.88	752719.57	789290.96	861455.36	866456.96	878778.96	842949.72	1115180.20	1022372.79	926851.97
Benefit : cost ratio	2.89	3.09	2.83	3.21	3.51	3.53	3.58	3.26	4.22	4.05	3.84

factor for its adoption by farmers. Different studies conducted in various parts of the globe proved that INM packages are superior to any other fertilizer management in respect of economics of cultivation in different crops. Marathe and Bharambe (2007) obtained complete supremacy in treatment using INM packages with 50% RDF +50% FYM over the inorganic fertilizers with a highest cost benefit ratio of 4.59 in sweet orange cv. Mosambi. Our study is in the line of conformity with the findings of Chundawat *et al.* (1983), Borges *et al.* (1994), Kulkarni *et al.* (1996), Duraiswami *et al.* (1999) and El Naby (2000), who reported different INM packages including organic manures and biofertilizers with inorganic fertilizers in different combinations in getting the maximum returns per unit as compared to the inorganic fertilizers alone.

The overall findings in terms of production and economic returns with eleven components of integrated nutrient management in the present study revealed that INM package having 100 per cent recommended dose of NPK in combination with FYM, VAM, *Azospirillum,* PSB and *Trichoderma harzianum* significantly increased the yield of tissue cultured banana cv. Grand Naine with maximum economic returns and highest benefit-cost ratio to the farmers. Hence, it can be concluded that, this INM package is best economically viable and sustainable, resource use efficient and an excellent approach for sustainable production, income generation and employment opportunity for the banana growers of Mizoram.

REFERENCES

Awasthi R P, Godara R K and Kaith N S. 1998. Interaction effect of VA-mycorrhizae and *Azotobacter* inoculation on micronutrient uptake by peach seedlings. *Journal of Horticulture* **11**: 1–5.

Bhalerao V P, Patil N M, Badgujar C D and Patil D R. 2009. Studies on Integrated Nutrient Management for tissue cultured Grand Naine Banana. *Indian Journal of Agricultural Research* **43**: 107–12.

Borges A L. 1994. Liming and fertilizing banana. CNPMF Report (Musa Doc. 1999), pp 2.

Chundawat B S, Dave S K and Patil N L. 1983. Effect of sources of nitrogen on yield and economics of banana cv. Basrai. *Haryana Journal of Horicultural Science* **12**: 156–9.

Duraiswamy R, Mani A K and Balasubramaniam P. 1999. Effect of fertilizer nitrogen, *Azospirillum* and organics on yield and nutrition of rainfed tomato. *South Indian Horticulture* **47:** 234–6.

El- Naby S K M A. 2000. Effect of banana compost as organic on growth, nutrient status, yield and fruit quality of Magharabi banana. *Assiut Journal of Agricultural Science* **31**:101–14.

Hazarika T K. 2011. 'Evaluation of Integrated Nutrient Management Packages for growth, yield and quality of banana cv. Grand Naine in Mizoram'. Ph D thesis, Mizoram University, Aizawl, India.

Hazarika T K, Nautiyal B P and Bhattacharyya R K. 2011. Effect of INM on productivity and soil characteristics of tissue cultured banana cv. Grand Naine in Mizoram, India. *Progressive Horticulture* **43**: 30–5.

Jaipaul, Sharma S, Dixit A K and Sharma A K. 2011. Growth and yield of capsicum (*Capsicum annum*) and garden pea (*Pisum sativum*) as influenced by organic manures and biofertilizers. *Indian Journal of Agricultural Sciences* **81** (7): 637–42.

Kulkarni B S, Nalwadi U G and Giraddi R S. 1996. Effect of vermicompost and vermiculture on growth and yield of china aster (*Callistephus chinensis* Nees) cv. Ortrich Plume Mised. *South Indian Horticulture* **44**:33–5.

Kumar D, Pandey V and Anjaaneyulu K. 2008. Effect of planting density and nutrient management on growth, yield and quality of micro-propagated banana Rasthali Pathkapoora (AAB). *Indian Journal of Horticulture* **65**: 272–6.

Marathe R A and Bharambe P R. 2007. Growth, yield and quality of sweet orange cv. Mosambi in response to INM in vertisols of central India. *Indian Journal of Horticulture* **64**:274–7.

Marathe R A, Chandra Ram, Maity A, Sharma J and Jadhav V T. 2011. Effect of different microbial inoculants on soil properties, nutrient acquisition and growth of pomegranate (*Punica granatum*). *Indian Journal of Agricultural Sciences* **81 (7):** 622–7.

Marwaha B C. 1995. Biofertilizers-A, supplementary source of plant nutrient. *Fertilizer News* **40**: 39–50.

Patel V B, Singh S K, Ram Asrey, Lata Nain, Singh A K and Singh Laxman, 2009. Microbial and inorganic fertilizers application influenced vegetative growth, yield, leaf nutrient status and soil microbial biomass in sweet orange cv. Mosambi. *Indian Journal of Horticulture* **66**: 163–8.

Singh A and Singh J N 2009. Effect of biofertilizers and bioregulators on growth, yield and nutrient status of strawberry cv. Sweet Charlie. *Indian Journal of Horticulture* **66**: 220–4.

Thangaselvabai T, Leo Justin G, Nirmal C, Johnson S B and Jayasekhar M. 2009a. Influence of nutrients on the quantitative and qualitative traits of banana. *Indian Journal of Agricultural Research* **43**: 274–8.

Thangaselvabai T, Suresh S, Prem Joshua J and Sudha K R. 2009b. Banana nutrition – A review. *Agricultural Review* **30**: 24–31.

Umar I. 2007. 'Studies on integrated nutrient management in strawberry (*Fragaria* × *ananassa* Duch.) cultivar Chandler.' Ph D thesis, S K University of Agricultural Sciences and Technology of Jammu, Udheywalla, Jammu, J&K.

Umar I, Wali V K, Kher R and Jamwal M. 2009. Effect of FYM, urea and *Azotobacter* on growth, yield and quality of strawberry cv. Chandler. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* **37**: 139–43.

Yadav G S, Debnath C, Datta M, Ngachan S V, Yadav J S and Babu S.2013. Comparative evaluation of traditional and improved farming practices in Tripura. *Indian Journal of Agricultural Sciences* **83 (3)**: 310–4.